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PROGRAM OF THE

LOS ANGELES MEETING

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MARCH 5, 1927

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AMERICAN PHSYICAL SOCIETY

LOS ANGELES MEETING, MARCH 5, 1927

The 144th regular meeting of the American Physical Society will be held at the University of California, Southern Branch, Los Angeles, California, in the main lecture room of the Department of Physics, on Saturday, March 5.

Titles and abstracts are given in the following pages in order of presentation:

Morning session, 10 o'clock, papers 1–12.

Afternoon session, 2 o'clock, papers 13–25.

Other meetings of the current season are as follows:

145. April 22–23, 1927. Washington.
146. June 22–25, 1927. Pacific Coast Section at Reno, Nevada.
147. November 25–26, 1927. Chicago.
148. December 27–30, 1927. Nashville, Tenn. Annual Meeting.

D. L. WEBSTER,
Local Secretary for the Pacific Coast,
Stanford University, California.

February 19, 1927.

PROGRAM

1. Effect of oil in storage on lightning discharge. ROYAL W. SORENSEN, California Institute of Technology.—As a part of a large laboratory program to determine means or protection against direct hits or induced sparks in oil reservoirs as produced by cloud charges or lightning strokes, a number of tests were made to determine the ability of oil to hold an electric charge or to influence the direction of discharge between electrodes on one of which oil is placed. These experiments show that as soon as oil is placed in an electric field circulation begins. Because of this oil does not act as a solid dielectric. That is, local charges cannot accumulate at spots on an oil surface. This point was proven by placing pans containing oil in a strong electric field produced by high-potential direct current. Charges could be detected on the surface of the oil only while the field was maintained between pan and an electrode above the oil. No charges were found after the source of energy was disconnected. Also, charged electroscopes when placed in contact with the surface of the oil will readily discharge. Other tests with the oil pan positive and the electrode above the pan negative also show that oil on a positive terminal does not influence spark discharge as does solid dielectrics placed near the positive terminal.

2. On the electrostatics of the thunderstorm. A. W. SIMON, California Institute of Technology.—The electrostatic phenomena of the thunderstorm are analyzed in somewhat greater detail than has been done before. The action of the storm cloud is shown to be analogous to the generation of charges and potentials by rubbing together two dissimilar substances, i. e., the fundamental experiment of frictional electricity. The generation of potentials and electric stresses by precipitation of charged rain and by the induction of charges at the earth's surface are discussed. It is shown that the "impulsive rush" lightning discharge of Lodge is electrostatically impossible. A relation between the change of gradient in an area, the polarity of the charged rain falling in the area, and the polarity of the overhead cloud is developed. Approximate numerical relations between gradients, charges, and potentials are deduced. Applications of the results to lightning protection are made.

3. Striking potentials of metallic arcs in vacuo. S. H. ANDERSON, University of Washington. —Simmon's theory of the minimum striking potential of metallic arcs in vacuo (Phil. Mag. **46,** pp. 816–819, 1923) has been tested with electrodes of magnesium and of aluminum. The electrodes were sealed into Pyrex glass bulbs (with one electrode adjustable by an electromagnet outside) so that a high vacuum could be produced and maintained. With pressures of 10^{-4} bars, 1 bar and 10 bars, respectively, a persisting arc could *not* be struck with either kind of electrodes when potentials as high as 150 volts were applied. With a pressure of 100 bars of air, persisting arcs were struck with both the magnesium and aluminum electrodes. For magnesium the applied potential difference was 45 volts. While burning, the potential difference was 26 volts and the current 4 amperes. For aluminum the applied potential difference was 88 volts. While burning, the potential difference was 36 volts and current 3.1 amperes. It appears that the striking potential is dependent upon a gaseous atmosphere as well as the nature of the electrodes.

4. Vacuum switch. H. E. MENDENHALL, California Institute of Technology.—Previous experiments on denuding metals of gases by various kinds of treatment have shown that arcing between contact points became continuously more and more difficult with further denudation, and suggested the possibility of interrupting large currents at high potentials in a practically perfect vacuum without appreciable arcing. Experimental tests have now been carried up to the point where about 1000 amperes alternating current have been successfully interrupted at about 45,000 volts with practically no arcing. This report contains the details of these experiments.

5. Factors influencing thermionic emission. A. KEITH BREWER (National Research Fellow), California Institute of Technology.—The thermionic emission from gold has been determined in the presence of various gases at atmospheric pressure. Both the positive and

negative currents follow the Richardson equation, although there is no semblance of saturation. A distinct proportionality exists between the difference in the values of b, (Δb), for the positive and for the negative emission, and for the corresponding differences in the values of T, (ΔT). Again, when an emitter, such as iron, is slowly oxidized over, there is a gradual increase in the values of b and T for the positive emission which is concomitant with a corresponding decrease for the negative emission. When the value of b is the same for ions of each sign T is likewise the same. The relationship between Δb and ΔT is accounted for by the presence of an intrinsic force, possessing the properties of a resultant field, existing at the surface. The changes in T and b accompanying the oxidation of a surface is doubtless due to the presence of the negative oxygen ions of the oxide neutralizing the positive intrinsic field, and upon high oxidation, actually giving rise to a resultant negative field.

6. Mobilities of ions in hydrogen gas mixtures and the constitution of the ion. LEONARD B. LOEB, University of California.—Recent measurements of mobilities in HCl-air mixtures indicated that there was an increased concentration of HCl gas in the neighborhood of the ion, the effect being greatest for the negative ion. Experiments in mixtures of hydrogen with ether, and hydrogen with NH_3 have given the following new facts. Small amounts of ether *lower* the mobility of the *positive ion* in H_2 *abnormally* while the effect on the negative ion can be calculated from the law of mixtures. *Minute traces of* NH_3 in H_2 *increase* the mobility of the *positive ion to nearly that of the negative ion.* Further additions of NH_3 *lower* both positive and negative mobilities in H_2 faster than the law of mixtures demands, but not as fast as earlier experiments in air—NH_3 mixtures led one to believe. In a mixture of NH_3, ether, and H_2 the effect on the positive ions was to be calculated from the observed combined effects of what the ether alone produced added to what the NH_3 would have produced on a normal positive ion in H_2 without the increase due to NH_3 alone. These results can only be explained on the assumption that the ionized positive molecule or atom adds to itself at least one more molecule to make a positive ion. This conclusion is in accord with a similar conclusion recently drawn by Erikson on the basis of other evidence.

7. Measuring the evaporation from a body of water. BURT and PAUL RICHARDSON. California Institute of Technology.—The method developed at this Institute by Cummings (Phys. Rev., **25,** 721, 1925; Jour. Electr., **46,** 491) and Bowen (Phys. Rev., **27,** 779, 1926) for measuring the evaporation from a body of water was employed under dissimilar circumstances in Pasadena and at Fort Collins, Colorado, to obtain results which show the relative importance of each factor in the evaporation equation of Cummings and Bowen: $I=S+LE(1+R)+U$, where I is the radiant energy integrated over any time interval, or more specifically, the solar and sky radiation in calories per sq. cm. corrected for reflection and back radiation. S is the heat energy represented by change in temperature of the water. LE is the latent heat represented by the evaporation during the same interval, L being the latent heat of evaporation, R represents the ratio of heat losses by convection and by evaporation, while U represents a relatively small correction for other losses.

8. Motion of an airship in a variable horizontal wind. H. BATEMAN, California Institute of Technology.—In the well known method of aerial navigation by dead reckoning the analysis is very simple when there is no wind or when the wind is uniform in velocity and direction. In the case of a variable wind the problem is complicated and so much is unknown that few results of importance can be expected. The problem is, however, mathematically interesting. Taking the case in which the wind blows in one direction and assuming that the propeller thrust depends linearly on the relative velocity, the problem reduces to a boundary problem for a certain type of linear differential equation of the second order. A solution of the problem is obtained for a case in which the wind drops steadily from one velocity to another.

9. End corrections of pipes as a function of frequency. FLOYD C. OSTENSON and S. H. ANDERSON, University of Washington.—The correction due to the reflection of sound waves from the open end of a brass pipe has been measured by the usual method of finding two or more resonant lengths. Points of resonance were located using as a detector a telephone con-

nected to a galvanometer through a thermionic tube as a rectifier. With a tube 10 cm in diameter there is a small constant increase in the end correction with increasing frequencies from 128 v.p.s. to 832 v.p.s., beyond which the increase becomes very rapid. With a tube 7.62 cm in diameter there is a maximum in the end correction at 640 v.p.s. beyond which there is a decrease.

10. The measurement of sound-absorption in a room. V. O. KNUDSEN, University of California, Southern Branch.—The differential equation for the status of sound energy in a room yields two useful relations for determining a, the sound-absorption of a room. These relations are (1), $a=4E/vI_{max}$, for steady state; and (2), $I=I_{max}e^{-avt}/4V$, for decay. (E= rate of emission of source, v=velocity of sound, I=average energy density, V=volume of room.) The usual method, developed by Sabine, makes use of (2), measuring the time t for a known diminution of intensity I. The advantages and limitations of this method, and also of two other possible methods, one involving the measurement of the average value of I_{max}, and another involving measurements of oscillograms of the decay of sound, are discussed. With suitable instruments, the measurement of I_{max} seems to be the most satisfactory method for determining a. Preliminary experiments and results are described which indicate that a, determined from (1) by intensity measurements, agrees within 2% of the value obtained from reverberation measurements. The frequency of the sound-source used varies periodically from 408 d.v. to 629 d.v. This shifts the interference pattern sufficiently to give approximately an average intensity of sound at any point in the room not too near the source.

11. Change of elastic frequencies in solid bodies with pressure. F. ZWICKY, California Institute of Technology.—The general theory for the constituent forces in heteropolar crystals has been developed by Born and other investigators. As a new conclusion of this theory a formula for the shift of frequency of residual rays with pressure is deduced. The shift corresponding to a pressure of 10,000 atm. amounts approximately to 7μ in the case of NaCl (residual rays at 50μ). Qualitative conclusions may be drawn with respect to the dependence of elastic frequencies on pressure in any crystal. Combining these results with a suggestion made first by Grueneisen, a rational explanation can be given for the effect of pressure on the specific electric conductivity of metals, this conductivity being in general increased with pressure. The relation of our results on conductivity to those obtained previously by Grueneisen and Bridgman in a quite different way, is discussed.

12. A vertical seismometer. SINCLAIR SMITH, Mount Wilson Observatory.—An investigation of the properties of a flat spring when bent into a bow by two opposing collinear forces showed that over a limited range, the ratio of the total force to the force per unit extension becomes large. This property was made use of in the construction of a small vertical seismometer. Using a spring 12 cm long in a modified Galitzin form of instrument having a steady mass of 100 g. a period of 12 seconds was obtained. This instrument, however, differs from the Galitzin form in that it has a much larger range of stability and does not require such critical adjustments.

13. Measurement of wave-length in water. ARTHUR W. NYE, University of Southern California.—A transmission grating was submerged in a trough of water and mounted on the stage of a spectrometer in the usual position. A window behind the grating allowed parallel light to enter at right angles to the window and grating. The diffracted first and second order spectra were received by the telescope as usual, except that the front surface of the objective was in water. A watertight flexible rubber connection was provided so that the front of the objective could remain in water, but allow the telescope to be swung freely to observe the spectral lines. The usual equation then applied but the wave-lengths as calculated were the lengths in water. The inverse ratio of these to the accepted values in air should give the air-water index of refraction. The results showed that the index of refraction differed not more than 0.0025 from the accepted values, at any point. Several prominent lines of Hg and Na were used, ranging from about 4000A to 6500A.

14. New infra-red absorption bands in methane. JOSEPH W. ELLIS, University of California, Southern Branch.—A recording infra-red spectrograph was employed to examine the absorption spectrum below 2.8μ of an 87.5 cm cell of pure methane. Five new absorption bands were found at 1.15μ, 1.37μ, [1.66μ, 1.72μ], and 1.80μ. Those at 1.66μ and 1.72μ are assumed to be the partially resolved first harmonic of the well-known fundamental at 3.33μ, while the 1.15μ maximum is interpreted as its unresolved second harmonic. The deviation from a true harmonic relationship is consistent with theory. The 1.37 and 1.80μ bands are doubtless the $(\nu_3'+\nu_4)$ and $(\nu_1+\nu_4)$ combination bands, where ν_3', ν_4 and ν_1 are the frequencies of the 1.69, 7.67 and 2.37μ bands respectively. The latter two values, as well as that at 3.33μ, are from measurements by Cooley (Astrophys. J., **62**, 73 (1925).), and the notation is consistent with his. The theoretical values of the above two combination bands are 1.38 and 1.80μ respectively. The degree of complexity recorded by Cooley in the 2.35μ region is also observed in this investigation. As a result of a check on the previous calibration of the instrument the wave-length values recorded in this abstract are slightly inconsistent with all values previously published by the writer. This correction will be more fully discussed elsewhere.

15. A study of the infra-red solar spectrum with the interferometer. HAROLD D. BABCOCK, Mount Wilson Observatory.—*Solar wave-lengths in the infra-red.*—The solar spectrum in the interval λ6869–8980 has been photographed on plates sensitized with *neocyanine* through interferometers crossed with a concave grating. Of the 507 *lines measured*, 176 are of solar origin; most of the remainder are probably lines of terrestrial water vapor. The *wave-lengths* were measured in terms of oxygen band lines due to terrestrial absorption and are expressed on the *neon scale. Identification of solar lines.*—The measurements have been used for a revision of the identification of solar lines, but refined laboratory wave-lengths are much needed for further work. The more prominent solar lines still awaiting identification are listed. *Differences between solar and terrestrial wave-lengths.*—In the absence of precise laboratory data for vacuum spectra in the infra-red, the new solar wave-lengths are compared with interferometer measurements on the spectrum of a short iron arc at atmospheric pressure. This brings out clearly the correlation of multiplet grouping, excitation potential and behavior under increased excitation with the combined influence of pressure displacement and pole effect. The data, though not definitive, are consistent with the gravitational displacement predicted by Einstein.

16. The effect of added gases on ammonia decomposition by optically excited mercury vapor. A. C. G. MITCHELL and R. G. DICKINSON, California Institute of Technology.—Ammonia decomposition has previously been shown to be sensitized to the mercury line 2537A by the presence of mercury vapor. In the present work the effect of added hydrogen, nitrogen, and argon on the rate of this decomposition has been studied, and the results correlated with the quenching of fluorescence of mercury vapor by these gases. It was found that with an ammonia pressure of 3 mm, a hydrogen pressure of about 0.1 mm suppressed the rate of decomposition by 50 percent; at lower ammonia pressures even less hydrogen was required. From the results of experiments at different ammonia and hydrogen pressures, the ratio of the efficiency of activation of ammonia by excited mercury, to the efficiency of de-activation of excited mercury by hydrogen has been estimated to be about 3×10^{-2}. On the other hand, several tenths of a millimeter of either argon or nitrogen were found to be without effect, as would be anticipated from the results of fluorescence experiments.

17. On King's classical theory of atomic structure. BORIS PODOLSKY, California Institute of Technology.—An analysis of King's paper (A Classical Theory of Atomic Structure and Radiation, Mercury Press, Montreal) shows that King assumes all electrons spinning with the same angular velocity. In motion the electron experiences a Lorentz-Fitzgerald contraction which is supposed to cause a precession. By assuming that the frequency of precession must equal the frequency of incident radiation in the case of photo-electric phenomena, and to an integral multiple of the orbital frequency in the case of radiation King obtains a picture of the quantum mechanism. There are, however, grave objections against this ingenious hypothesis. It is shown in the present paper that (a) the electron could not have a precession and absorb energy without changing the frequency of precession, (b) the electron cannot have a precession,

(c) the picture is undesirable, for the precession of the electron (due to causes other than those discussed by King) has found its place in explaining the normal doublets and triplets, i. e. small changes of frequency and not the whole effect.

18. Fine structure of the Balmer lines of hydrogen. NORTON A. KENT, LUCIEN B. TAYLOR and HAZEL PEARSON, Boston University.—Using two optical trains (1) two crossed Lummer plates, the larger of resolving power 670,000, and (2) an echelon of resolving power 660,000, with a vacuum tube cooled with liquid air, the writers have determined the wave-length difference between the two well known components, λ' and λ'' ($\lambda' > \lambda''$) of Hα, Hβ and Hγ. The doublet separations are shown in the table together with those given by Houston, which latter are in our estimation, the most reliable thus far obtained.

	Houston	Kent, Taylor and Pearson	
Current density	250	25	13 ma./sq. cm
$\Delta\lambda$ for Hα	0.1358	0.1370	0.1391 Angstroms
$\Delta\lambda$ for Hβ	.0782	.0791	———
$\Delta\lambda$ for Hγ	.0665	.0669	———

Our values are higher but this is not to be wondered at, because of the different current densities employed. A very reliable Lummer plate spectrogram, taken at 13 milliamperes per sq. cm, yields 0.1391 for Hα, which is in harmony with such a current change. Microphotometer curves of *enlargements* of the original Lummer plate negatives reveal another component in λ', unresolved but unquestionably present, in Hα, Hβ and Hγ. Hansen noticed assymmetries here in Hα and Hβ. Further these are indications of another component in λ''. The *magnitudes* of these six new components all agree well with the theoretical magnitudes on the spinning electron theory: their *positions* are in all cases too far toward the red—an effect probably due to the photographic processes involved.

19. The fine structure of the helium arc spectrum. WILLIAM V. HOUSTON, National Research Fellow, California Institute of Technology.—By means of the compound Fabry-Perot interferometer it has been possible to show that both the sharp series line 7065 and the diffuse series line 5876 of the orthohelium spectrum are triple. Under conditions which made reversal very improbable the strong component was shown to consist of two lines with intensity ratio about 5:3. This, with the weak component, makes a triplet of normal intensity ratios, and confirms the theoretical expectation that the helium spectrum should consist of singlets and triplets. The 2^3P level is inverted with separations 0.992 cm^{-1} and 0.071 cm^{-1}. This is in good agreement with the quantitative theory of Heisenberg. The D levels can be estimated from the 5876 line to be partly inverted. This experimental verification of the theoretical expectation removes the helium spectrum from its anomalous position among the spectra of the elements.

20. Series spectra of ionized phosphorus, P II. I. S. BOWEN, California Institute of Technology.—One hundred and ten of the strong lines of P II have been classified as arising from various combinations between thirty-two terms of the triplet system. The observed terms include nearly all the terms of the triplet system that are predicted by the Russell-Heisenberg-Pauli-Hund theory for the s^2p^2, sp^3, $s^2p \cdot 4s$, $s^2p \cdot 5s$, $s^2p \cdot 4p$, $s^2p \cdot 3d$, and $s^2p \cdot 4d$ configurations. The lowest level is the $^3P_0$ term of the s^2p^2 configuration. This term has a value corresponding to an ionization potential of 19.82 volts.

21. Relationships in the spectra of the elements of the first row of the periodic table. R. A. MILLIKAN and I. S. BOWEN, California Institute of Technology.—Practically all of the strong ultra-violet lines that can be emitted by the atoms of the first row of the periodic table in all stages of ionization of the valence electrons have now been obtained and a general statement of the relationships between the frequencies of these lines has been formulated. These relationships are presented most simply and compactly in a new graph here given which depicts the generalized form of the Moseley law in the field of optics. Similarly a table of the ioniza-

tion potentials of the atoms of the first row in all stages of ionization is here presented. Furthermore the predictions of the Russell-Heisenberg-Pauli-Hund theory as to the structure of spectra in general have been completely verified in the case of these light elements.

22. The reflection of x-rays by crystals as a problem in the reflection of radiation by parallel planes. SAMUEL K. ALLISON, University of California.—It is pointed out that the previous solutions of the problem of the reflection of radiation by parallel planes by Lamson and Gronwall are physically incorrect since the intensities, not the amplitudes, of contributions from individual planes, have been added. It is shown that a mathematical method due to Darwin leads to a solution identical mathematically with those of Lamson and Gronwall. Using this result, the intensity of reflection is evaluated for certain ranges of the constants directly related to the reflected and transmitted amplitudes due to a single plane.

23. Direction of photo-electric emission. D. H. LOUGHRIDGE, California Institute of Technology.—Cloud expansion photographs of the photo-electrons produced in hydrogen, air, and argon by means of the $K\alpha$ radiation of M_0 show that the most probable direction of emission is the same for all three gases, and forms an angle of about 70° with the x-ray beam. These angles have been measured by means of a stereoscopic comparator specially built for the purpose. The total number of tracks measured is 443. Distribution curves plotted with number of tracks starting at a given angle with the x-ray beam against the angle show a narrower peak for hydrogen than for the argon. This qualitatively supports the view that the distribution is due to secondary scattering by the electrons in the atoms through which the photo-electron passes and that the initial direction of emission may be constant for a definite wave-length and depend only on the radiation.

24. The velocity and number of the photo-electrons ejected by x-rays as a function of the angle of emission. E. C. WATSON, California Institute of Technology.—Magnetic spectra of the electrons ejected by x-rays from thin metallic films at angles ranging from 0° to 180° with the direction of the x-ray beam have been obtained by the method of Robinson, de Broglie, and Whiddington. To the degree of accuracy of the measurements (0.5 percent) the maximum velocity of ejection is exactly the same in all directions. With thin foils of the heavier elements the numbers of electrons leaving the foil with this maximum velocity in the various directions is approximately the same. With foils of the very light elements, or with sputtered films so thin that Wentzel's criterion for single nuclear scattering holds, the number of electrons leaving the foil is greatest in a direction a little forward of perpendicular to the direction of the x-ray beam. The number of electrons leaving in other directions can be calculated by means of the theory of scattering, if the assumption is made that all the electrons start out from the atom in the same direction.

SUPPLEMENTARY PROGRAM

25. Spacial distribution of the photo-electrons ejected by x-rays. E. C. WATSON, California Institute of Technology.—The experiments of Wilson, Auger, Bothe, Bubb, Loughridge, and Kirchner have shown that the most probable direction of the photo-electron tracks in a gas traversed by x-rays is nearly the direction of the electric vector of the incident wave, but with an appreciable forward component. There is, however, a very considerable variation in the direction of the tracks. Theories to account for this apparent emission from the atom over a wide range of angles instead of in a definite direction have been proposed by Bothe, Bubb, Auger and Perrin, and Wentzel. It can be shown, however, that scattering must be present in all the experiments in sufficient amount to account for the distribution in direction, and the theory of scattering leads to a distribution function which fits the facts much better than any of the more elaborate theories. Consequently the fact that the photo-electron tracks do not have one definite direction does not constitute evidence for orbital velocities inside the atom.